

"Indian summer." Prof. Charles F. Marvin, Chief of the Weather Bureau, has recently investigated this question by making a study of the temperature records for several long-period stations in the northeastern United States, supplemented by 45-year records from Weather Bureau stations scattered over the country.⁵⁷ The conclusion reached is that the annual record of daily mean temperatures is a smooth curve, without secondary maxima or minima, or of perceptible points of inflection. Such marked irregularities as are described by the terms "January thaw" or "May freeze," neither persist, nor do they have a real existence. In cases where these or similar irregularities appear in the means, they are the effect of a single occurrence, or of a few accidentally

recurrent unusual or extreme events, near or at the time in question. A study of the long-period temperature records kept at New Bedford, Mass., between 1813 and 1905, was made by the late Waldo E. Forbes.⁵⁸ The object of this investigation was to discover evidence for or against the occurrence of a cold spell in New England about May 10 ("Ice Saints"). It appears that cold weather as well as hot may be expected on May 10, and hot weather as well as cold on May 7 or May 13. "It is nevertheless possible that when the pulsations of the weather are better understood, May 10 may prove to be a sort of node and may serve as a point of departure for the study of weather waves."⁵⁹

ON THE DEPRESSIONS OBSERVED IN THE VALUES OF SOLAR RADIATION INTENSITY.

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While very warm or rainy summers and very mild or cold winters come directly to general notice, depressions, and in general all the abnormal variations in the values of the intensity of solar radiation measured at the surface of the earth, do not manifest themselves immediately to the eyes of observers and require a scientific demonstration by special instruments known as pyrheliometers and actinometers.

Yet the study of these depressions, or rather of all the variations that appear in the values of solar radiation observed at the surface of the earth, has an importance all the greater since it is indeed the solar energy that is, in the last analysis, the *spiritus movens* in all the atmospheric movements observed on the earth. In order to find an explanation of the very complicated variations of temperature of the air and of precipitation it is necessary to begin with the study of solar radiation.

For this reason, we believe it useful to discuss briefly the two great depressions in solar radiation that have occurred since the beginning of the twentieth century; these are the depressions of 1902 and 1913, which we have demonstrated from pyrheliometric and actinometric measurements made at Warsaw without interruption since the close of 1900.

It is important to add that these depressions observed at Warsaw have been discovered in the series of measurements made at other observatories in Europe and in America;¹ these depressions have consequently a world-wide character.

To establish the existence of these depressions in the values of solar radiation observed at Warsaw let us take the monthly maxima (Max. Q) of the intensity of solar radiation. Granted that radiation is subjected in the earth's atmosphere to influences that always tend to diminish it, the conclusion is easily reached that it is especially the maximum values in the diurnal and annual periods that are the most characteristic. Besides the conclusions reached by examination of the monthly maximum values of radiation are confirmed by the consideration of the monthly mean values and also by the obser-

vation of the duration of insolation (in hours) and by the calculation of the totals of insolation (in kg. cal.) to one sq. cm. of the normal horizontal surface.

Being unable, in the present paper, to enter into the details of the matter, let us note that the results of the observations and calculations are found in the following publications by the author:

1. Valeurs pyrhéliométriques et les sommes d'insolation à Varsovie pendant la période 1901-1913. Warsaw, 1914. (*Publications de la Société des Sciences de Varsovie.*)

2. Sur les dépressions en 1912 et 1903 dans les valeurs de l'intensité du rayonnement solaire. Warsaw, 1914. (*Comptes Rendus de la Société des Sciences de Varsovie.*)

In Table 1 are presented the departures of the monthly maximum values of solar radiation at Warsaw during the period from 1901 to 1918. The departures (relative to the means for 1901-1913 and 1914-1918) are calculated in gr. cal. per sq. cm. per minute. The departures for the five years, 1914-1918, are given separately because of change in the place of observation in the first half of 1914, when the apparatus (Michelson actinometer and Ångström pyrheliometer) were transferred from the building of the Musée d'Industrie et d'Agriculture, situated more in the center of the city, to the building of the Société des Sciences of Warsaw, about 2 km. distant from the former.

Although, especially on account of the smoke of the city, both points of observation are far from favorable for measurements of solar radiation, it is of consequence to note that the latter place seems to be the better and gives higher values.

NOTE.—The values for 1901-1913 were calculated and published by the author (loc. cit.); the values for 1914-1918 were calculated by the observer, E. Stenz, but have not been published.

In the months for which departures are not given, actinometric measurements could not be effected.

Table 1 shows immediately that certain periods present depressions. In calculating the values of max. Q (for m , 1.5 atm. and f , 7 mm.) there is obtained the following

⁵⁷ Charles F. Marvin: Are there Persistent Irregularities in the Annual March of Temperature? *MO. WEATHER REV.*, 1919, 47: 544-555. The same number of the *REVUE* also contains a useful annotated bibliography of this subject (pp. 555-565), by C. F. Talman.

¹ See Kimball, Herbert H.: Volcanic eruptions and solar radiation intensities, *MO. WEATHER REV.*, Aug. 1918: 46:355-356.

⁵⁸ Waldo E. Forbes: Ice Saints, *Am. Astron. Observatory Harv. Coll.*, vol. 83, pt. 1 1917, pp. 53-59.

⁵⁹ An early discussion of this subject may be found in C. A. Schott: Tables, Distribution and Variations of the Atmospheric Temperature in the United States and some Adjacent Parts of South America. *Smithson. Contr. to Knowl.* 277. Washington, D. C. 1876. pp. 192-194.

TABLE 1.—Departures (relative to means) of the monthly maximum values of the intensity (Q) of solar radiation at Warsaw.

Month.....	January.	February.	March.	April.	May	June.	July.	August.	September.	October.	November.	December.
m (atm.).....	3.5	2.5	2.0	1.5	1.5	1.5	1.5	1.5	1.5	2.0	3.0	4.0
f (mm.).....	3	3	4	5	6	8	9	8	7	6	4	3
Means Q (01-13).....	0.87	1.03	1.11	1.21	1.19	1.19	1.19	1.16	1.22	1.13	0.95	0.80

Departures in hundredths of Q.

1901.....	- 1	13	- 4	7	6	4	3	10	3	5	5	12
1902.....	0	8	- 7	2	-11	-6	8	6	10	- 2	-12	-13
1903.....	-20	-20	-17	-21	-25	-3	- 8	-16	-14	- 8	- 5	- 7
1904.....	-18	-13	- 3	- 3	7	-6	5	1	0	1	- 5	- 1
1905.....	1	- 3	- 1	2	9	0	2	4	8	2	- 6	13
1906.....	7	- 6	3	5	5	5	- 2	- 3	- 1	10	22	- 2
1907.....	- 1	- 4	0	1	4	-3	3	5	1	9	12	- 3
1908.....	8	-15	- 8	- 5	4	2	3	6	9	2	2	- 1
1909.....	0	- 1	2	- 4	6	1	0	3	0	- 4	-12	-13
1910.....	4	2	2	- 1	1	0	0	- 2	1	2	-12	-13
1911.....	-12	6	14	6	9	8	11	6	12	12	-23	-13
1912.....	32	17	- 1	12	- 5	3	-19	-16	-33	-30	-11	- 3
1913.....	-12	- 1	- 5	- 2	- 1	-3	- 3	- 1	5	1	-11	- 3
Means (1914-1918).....	0.91	1.09	1.21	1.31	1.30	1.24	1.25	1.29	1.34	1.18	1.06	0.87
1914.....	-20	- 4	- 9	- 1	- 3	5	3	3	- 6	- 2	1	- 3
1915.....	-15	- 6	4	4	1	2	6	3	1	8	- 6	- 1
1916.....	7	1	0	1	- 1	-3	- 6	-13	2	- 6	- 6	- 2
1917.....	13	5	- 4	- 4	- 5	-5	5	5	1	- 1	0	1
1918.....	13	5	7	- 6	- 5	3	4	3	2	1	12	4

march of annual departure in percentage of the respective means.

1901.....	4	1910.....	1
1902.....	- 1	1911.....	7
1903.....	-13	1912.....	-6
1904.....	- 3	1913.....	-3
1905.....	3	1914.....	-2
1906.....	4	1915.....	-1
1907.....	2	1916.....	-2
1908.....	0	1917.....	1
1909.....	2	1918.....	3

We are at once impressed by the very large negative departures in 1903 and 1912. On further examination of Table 1 it is seen that the months with particularly lowered intensity are grouped in a very strikingly consecutive manner; they continue from November, 1902 to February, 1904 (with a slight relative increase in June, 1903), and from July, 1912, to January, 1913.

During these two periods the monthly maxima of intensity (Q) of the solar radiation at Warsaw were diminished without interruption (relative to the means for 1901-1913), and this diminution generally exceeded 10 per cent.

Let it be noted that the maximum values of intensity (Q) of solar radiation have been reduced uniformly to the atmospheric thickness (m) and the vapor tension (f) indicated in the headings for the different months. In addition all the values of table 1 have been reduced to the earth's mean distance.

The depression of 1903 continued approximately 16 months (November, 1902-February, 1904); here are the departures.

November, 1902.....	-12	July, 1903.....	- 8
December, 1902.....	-13	August, 1903.....	-16
January, 1903.....	-20	September, 1903.....	-14
February, 1903.....	-20	October, 1903.....	- 8
March, 1903.....	-17	November, 1903.....	- 8
April, 1903.....	-21	December, 1903.....	-18
May, 1903.....	-25	January, 1904.....	-13
June, 1903.....	- 3	February, 1904.....	-13

In November and December, 1903, measurements of radiation could not be made on account of too unfavorable condition of the sky.

This depression was observed not only in Poland, but at Lausanne (Switzerland) and at Pavlovsk (Russia); it was due to the eruption of Mount Pelée on Martinique.

The depression of 1912 was no less marked than the preceding one, but it continued only 7 months—from July, 1912, to January, 1913. Here are the departures in hundredths of a gr. cal. cm² relative to the means for 1901-1913.

July, 1912.....	19	November, 1912.....	23
August, 1912.....	16	December, 1912.....	13
September, 1912.....	33	January, 1913.....	12
October, 1912.....	30		

This depression was observed at several places in Europe and also in North America: it appeared simultaneously and suddenly in July, 1912, as is seen from the following table in which are grouped the monthly maxima (not reduced) of intensity of solar radiation for two consecutive months in 1911 and 1912.

	July.			August.		
	1911 (gr. cal.).	1912 (gr. cal.).	Diff. (per cent).	1911 (gr. cal.).	1912 (gr. cal.).	Diff. (per cent).
Warsaw (Poland).....	1.33	1.03	23	1.22	0.99	20
Olczedajow (Podolia).....	1.33	1.01	24	1.28	1.067	17
Pavlovsk (Russia).....	1.34	1.02	24	1.30	1.00	23
Potsdam (Germany).....	1.37	1.13	18	1.33	0.97	27
Paris (France).....	1.25	0.96	23	1.22	0.95	22
Washington (United States).....	1.37	1.05	23	1.33	1.02	23

This large depression was due to the eruption of the volcano Katmai (Alaska) observed on June 6-8, 1912, as has been noted by Mr. H. H. Kimball in America.

Let it be noted that the famous eruption of the volcano Krakatoa gave rise to a depression in intensity of solar radiation as appears from the series of measurements made at Montpellier (France) during the period 1883-1900. The curve at Montpellier shows a very deep depression (-12 per cent) in 1885, although the depression includes four years, 1883-1886.

Another depression was observed at Montpellier in 1891; we are ignorant of its cause.

The period 1893-1902 seems to be free of depressions, as appears from an examination of actinometric measurements at Montpellier (until 1901) and at Pavlovsk (with uninterrupted series since 1893).

With reference to Table 1, it is important to note that if for some other months of the period 1901-1918 there

are found at Warsaw occasional monthly maxima that are diminished relative to the means these months are rather scattered. This character is frequent during the winter months when clear days are rare at Warsaw and changes in max. *Q* (large departures negative or positive) become very considerable, but they are of local character.

But if it is necessary to be extremely careful relative to lowered values in winter we can not pass without examination of depressions of even short duration observed in summer when, in general, the number of clear days is large enough and the conditions are favorable enough for actinometric measurements. After the last marked depression of 1912 the years following have been rather normal relative to annual means, as appears from an examination of Table 1.

However, there is noted the depression in the summer of 1916 with the following departures (in hundredths of a gr. cal., calculated at the Central Meteorological Institute of Poland by E. Stenz):

June.....	- 3	September.....	2
July.....	- 6	October.....	-6
August.....	-13	November.....	-6

At first we were disposed to believe that here there was a matter of a rather local depression observed at Warsaw, although the days with sun not veiled were

numerous enough and the sky appeared sufficiently pure. But the fact that the same depression was observed simultaneously at Florence and at Izana (Canary Islands) leads to the conclusion that here there is a matter of a phenomenon of more general character.

Let us note that the measurements at Florence are made with the Ångström pyrheliometer; the measurements at Izana (lat. 28° 15' N., long. 16° 57' W., elevation 2,100 meters) made with the Abbot actinometer (silver disk N. 25) have been published under the direction of the Central Meteorological Institute at Madrid.

The depression of the summer of 1916 was followed by atmospheric disturbances relative to optics and polarimetry, as has been demonstrated especially by Dorno at Davos (Switzerland). The cause of this depression has not been discovered; it is only admitted that it was not of volcanic origin. Let us add that this coincidence of depressions in the values of solar radiation and in the values of polarization does not always manifest itself; it occasionally happens that the diminution in the polarization of the sky is observed, although the values of intensity of solar radiation do not show parallel changes.

In closing this paper, let the attention of observers be called to the theoretical and practical interest of continuous measurements of the intensity of solar radiation made with tested apparatus.

PROLONGED PLANT ACTIVITY AT GRAND HAVEN, MICH., IN AUTUMN OF 1920.

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[Weather Bureau, Grand Haven, Mich., Dec. 20, 1920.]

Early in November of 1920 it was observed by many persons and commented upon in the newspapers that various wild plants were blooming later than usual in this vicinity. Up to November 10 no severe frosts had occurred, and there had been but three days with mean temperature below that generally necessary for plant growth, two of these having occurred late in October and one in November. As a consequence, the foliage of practically all the herbs, shrubs, and trees was still green. Though in previous years no systematic record with which to make comparisons had been kept, it was decided, early in November, to make notes during the rest of the season on the late blooming of wild plants¹ and the persistence of verdure. Accordingly, a suitable area was selected, and the vegetation thereon noted at intervals as long as growth continued. This tract is owned by Dr. Edward Hofma and embraces about 8 acres of lowland flats inclosed together with some marsh land by Grand River and one of its "ox bows." The ground selected is composed of quite firm soil, upon which flourish not only herbs but shrubs and small trees also. The characteristic vegetation of the adjacent marsh is cat-tail, reed, and wild rice.

A cold spell, with mean temperature somewhat below freezing, extended from November 11 to November 16, inclusive; but during this time a blanket of snow covered the ground, affording protection for the abundant herbage. The snow came in advance of the coldest weather; otherwise it is clear that the activity of practically all the vegetation would have been brought to a close in the second week of November. As it was, the leaves of the trees and shrubs—chokecherry, white dogwood, poplar, willow, etc.—were frozen at this time.

Beginning November 17 there was a period of warmer weather and the snow disappeared rapidly, while growing temperatures prevailed from the 18th to the 21st. On Thanksgiving Day, November 25, 20 species of wild plants were observed in bloom, which may safely be called an unusual number despite the fact that no previous records for comparison exist. These plants were the following: Dandelion, mallow, yarrow, white sweet clover, silvery cinquefoil (on adjacent uplands), common chickweed, peppergrass, blind gentian, common evening primrose, red clover, bouncing Bet, goldenrod (*Solidago altissima*), wild strawberry, white campion, beggar ticks (*Bidens* sp.), daisy fleabane (*Erigeron annuus*), common ragweed (bearing male and female flowers), smartweed (*Polygonum persicaria*), lamb's-quarters, and pansy (escaped from cultivation). Of these the first eight were more or less numerous, while only one or a few individual plants or clumps of the others were observed in bloom. A red raspberry bush bearing ripe and well-formed fruit was found. All the yarrows and evening primroses seen in bloom on this day were plants that had been bent over by the weight of the snow of mid-November and thus protected; and now also were partially sheltered by long, dried grass.

Though from the 25th to the 30th there was but little freezing weather, the mean temperature of only one day was as high as 42°, and there was but little sunshine. The ground was bare, but not frozen. No more evening primroses, bouncing Bets, goldenrods, silvery cinquefoils, beggar ticks, daisy fleabane, or lamb's-quarters were observed in flower after the 25th. On the 30th, however, the rest of the Thanksgiving Day list, as well as one plant of shepherd's purse, doubtless overlooked before, were still in bloom.

On December 5, 1920, a day with mean temperature 40°, from one to a few blooming plants of the following

¹ Acknowledgments are due H. T. Darlington, assistant professor of botany, Michigan Agricultural College, for determining certain plants the specific identity of which was in question.